Abstract: An interesting class of non-Gaussian stationary processes is obtained when in the harmonics of a signal with random amplitudes and phases, one allows also for frequencies to vary randomly. In the resulting models, the statistical distribution of frequencies determines the process spectrum while the distribution of amplitudes governs the process distributional properties. Since decoupling the distribution from the spectrum can be advantageous in applications, we thoroughly investigate a variety of properties exhibited by these models. A process in the considered class of models is uniquely defined by a triple consisting of a positive scale, a normalized spectrum (which is also the distribution of the frequencies), and a normalized Lévy measure determining the process distribution. We extend previous work that represented processes as a finite sum of harmonics, by conveniently embedding them into the class of harmonizable processes. Harmonics are integrated with respect to independently scattered second-order non-Gaussian random measures. We present a proper mathematical framework that allows for studying spectral, distributional, and ergodic properties. The mathematical elegance of these representations avoids serious conceptual and technical difficulties with the limiting behavior for discretized models while, at the same time, facilitates the derivation of their fundamental properties. In particular, the multivariate distributions are obtained and the asymptotic behavior of time averages is formally derived through the strong ergodic theorem. Several deficiencies following from the previous approaches are resolved and some of the results appearing in the literature are corrected and extended. It is shown that due to the lack of ergodicity, processes exhibit an interesting property of non-trivial randomness remaining in the limit of time averages.